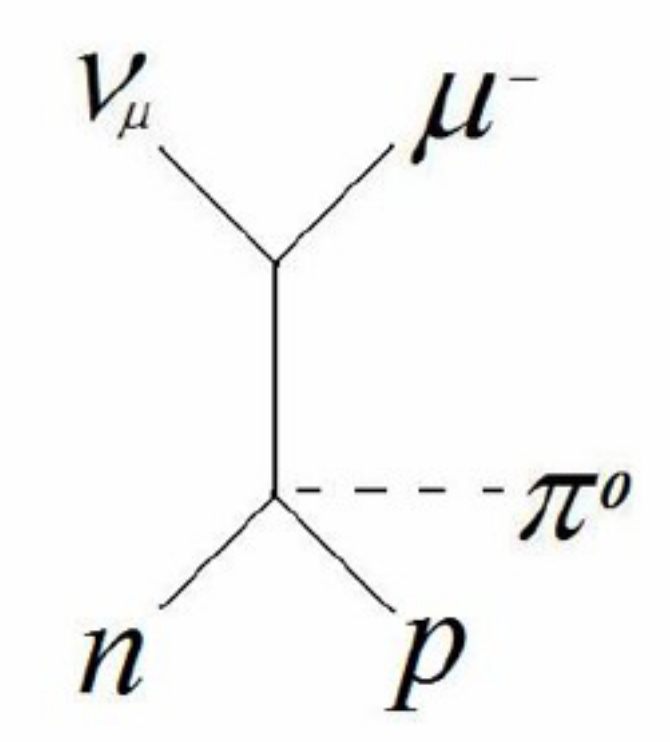
Progress on CC π^0 Filters

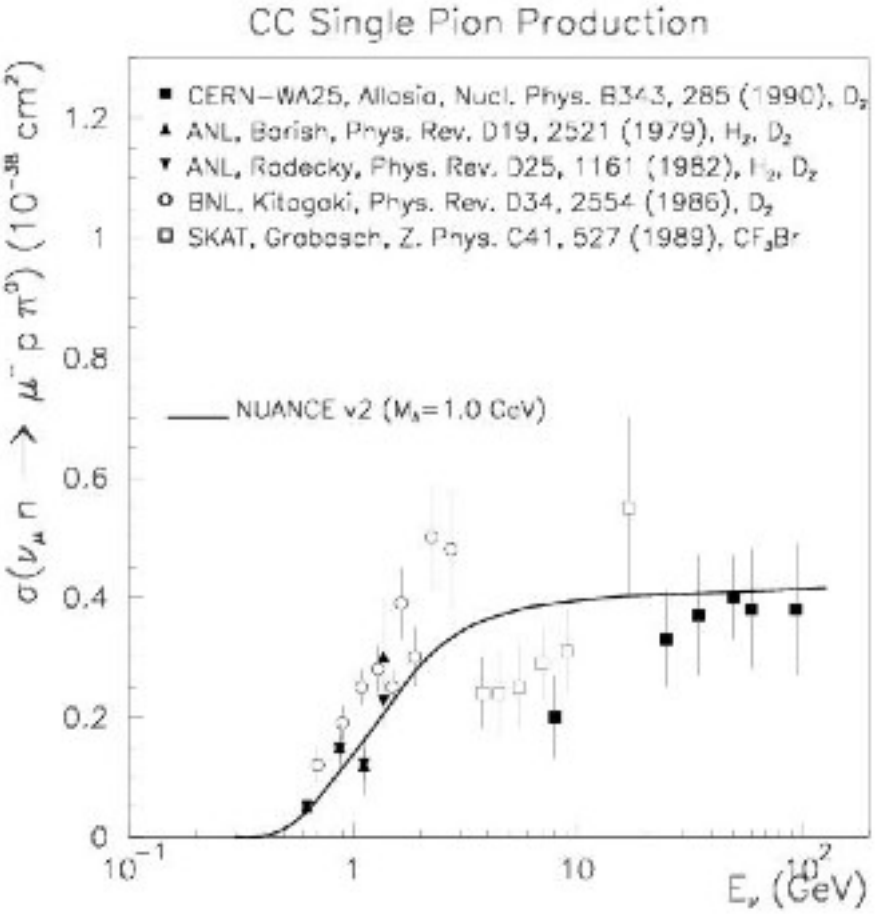


Overview

- CC π^0 applications and history
- Revision of Laura J.'s filter
  - I use May06 MC to plot variables that can distinguish CC π^0s from other events.
  - Retune cuts based on NUANCE number, as well as "effective" CC π^0s
  - Visible hadronic energy study
- Filter performance
  - Efficiency/purity
  - Data to MC comparisons

Applications of CC π^0 studies

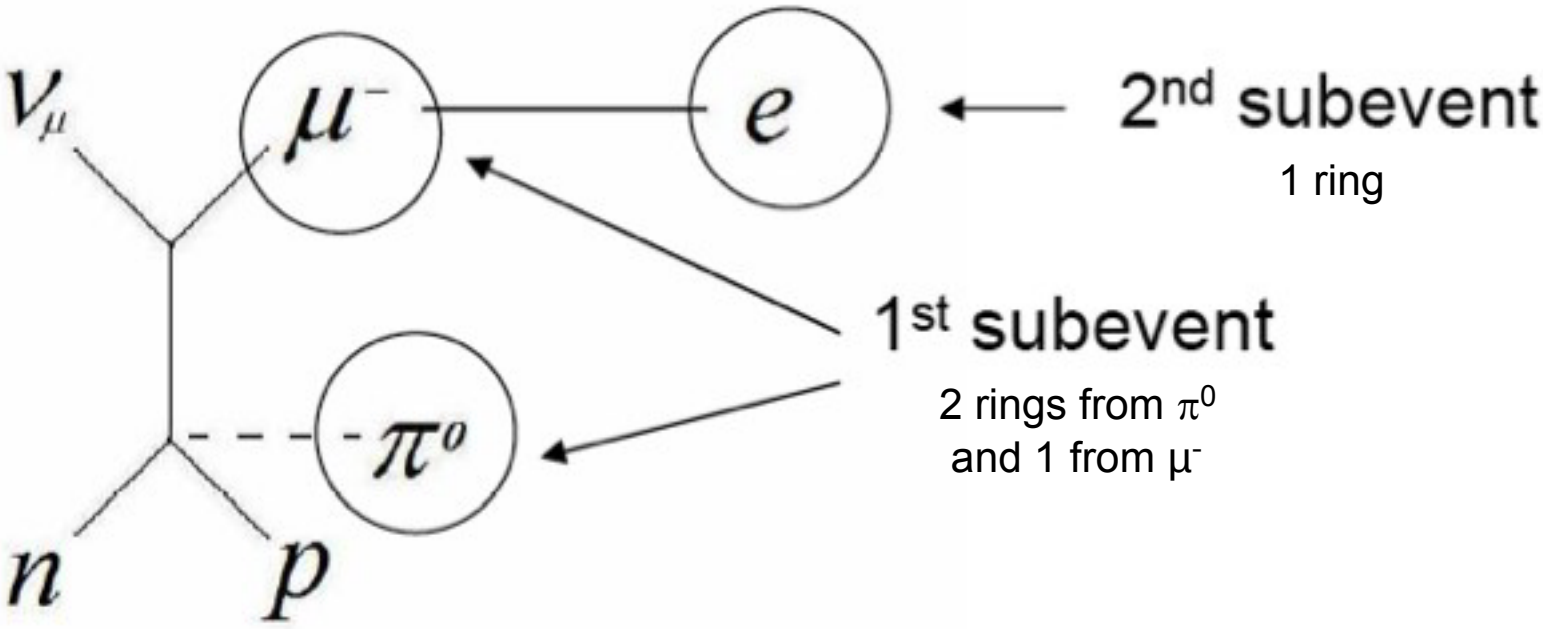
- There are few existing CC π^0 cross section measurements, especially on carbon targets.
- CC π^0 events are background for MiniBooNE neutrino oscillation analysis
- CC π^0 events come from resonant scattering only
  - Helps with coherent CC π^+ cross section studies



CC π^0s in the detector

- 3.8% of all neutrino interactions have the CC π^0 NUANCE number (Cross sections - May 06 baseline).
- 3.3% are “effective” CC π^0 interactions (My May06 studies; ~500K events).
  - Result in exactly one CC π^0 directly, or through a final state interaction (FSI) in the nucleus.
  - Example: π^+ converts to π^0 (reverse also occurs)
  - NUANCE number is ignored when speaking of effective π^0s.

Characterizing the Events



We don't have a 3-ring fitter, which makes reconstructing these events a challenge given our current tools

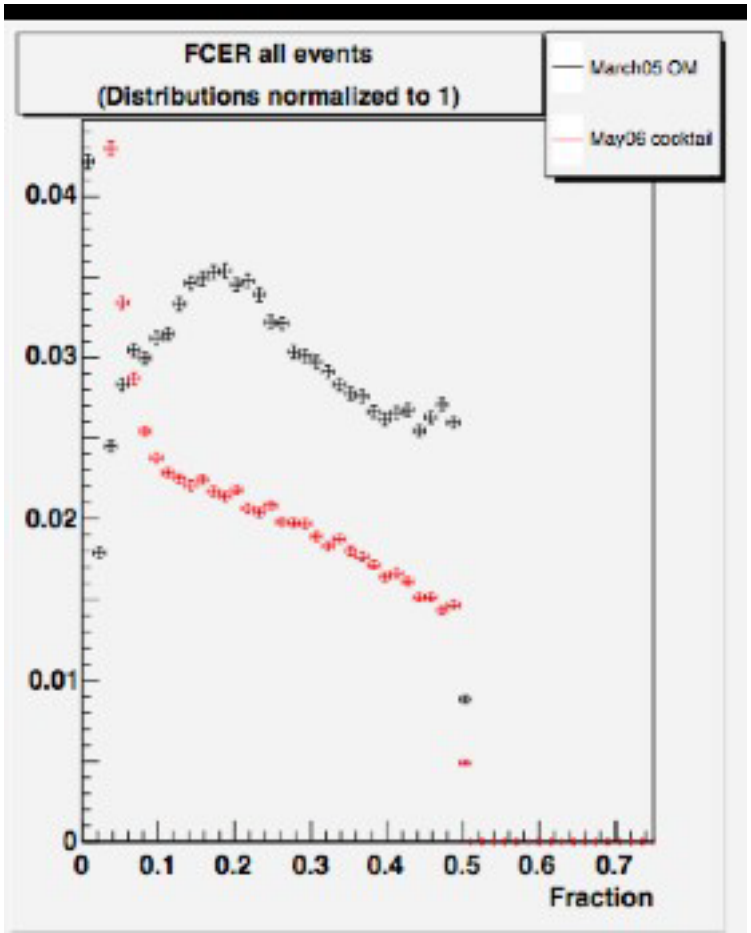
Identifying effective CC π^0s

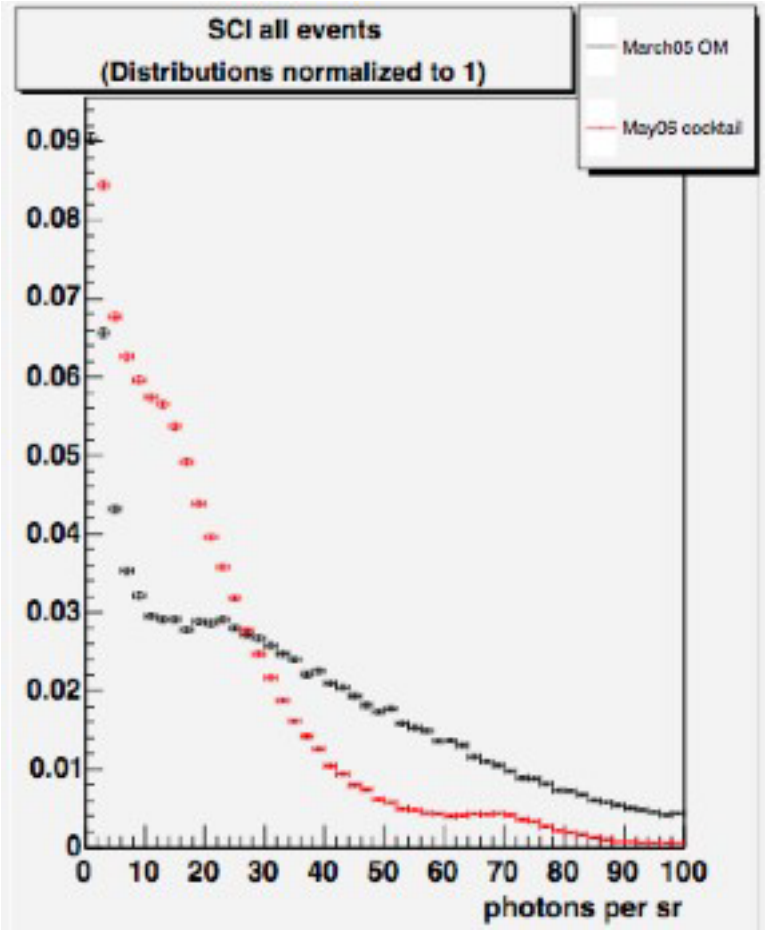
- Jon Link's code for NC π^0 (not yet submitted to the framework). Requires the following from MonteCarloEVNTChunk:
  - Exactly 1 π^0 that exits the nucleus
  - Two gammas with energies consistent with π^0 ancestor (Dalitz decay is taken into account)
  - No other mesons in the event
- Additional CC criteria
  - One μ^- and one e^-

Characterizing the events (cont.)

- Basic cuts to reject cosmics and leave only CC events:
  - StancuVars_nchunks = 2 (number of subevents)
  - 21 < THits[1] < 179 (2nd subevent tank hits)
  - Qtot[1] < 295 (2nd subevent total charge)
  - SCI[1] < 7 (2nd subevent stancu sci. light)
  - VHits[0] and VHits[1] < 6 (1st and 2nd subevent veto hits)
  - 4400 < AvgTTim[0] < 6200 (Average tank hit time)
  - Rvtx[0] < 500 (Stancu vertex radius)
- 24.4% of NUANCE CC π^0 pass (in MC)
- 25.1% of effective CC π^0 pass
- All of the following plots have these cuts

Some changes between March05 and May06 Monte Carlo

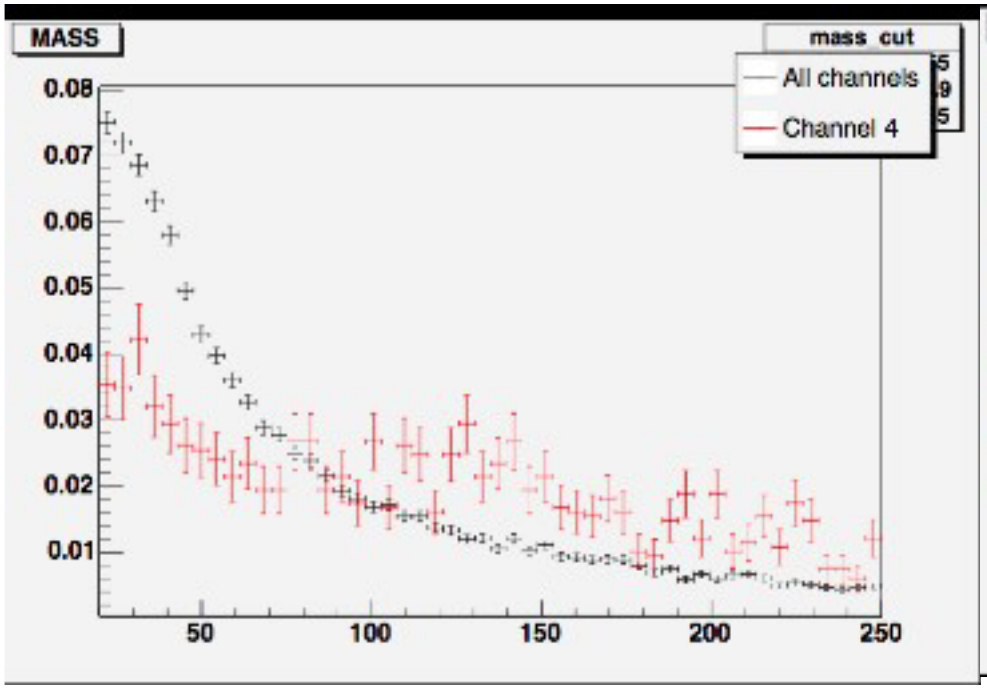




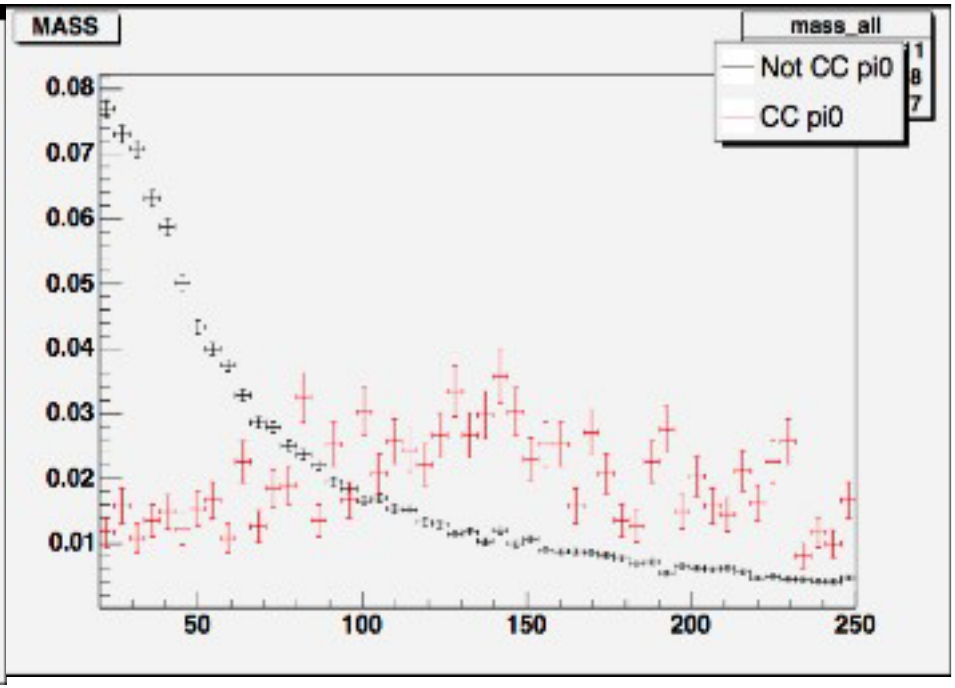
Laura J. designed her filter with the March05 MC.
Since then, the MC was changed to give better data agreement

May06 MC: Reconstructed π^0 mass
StancuPi0Chunk_mass[0]

NUANCE



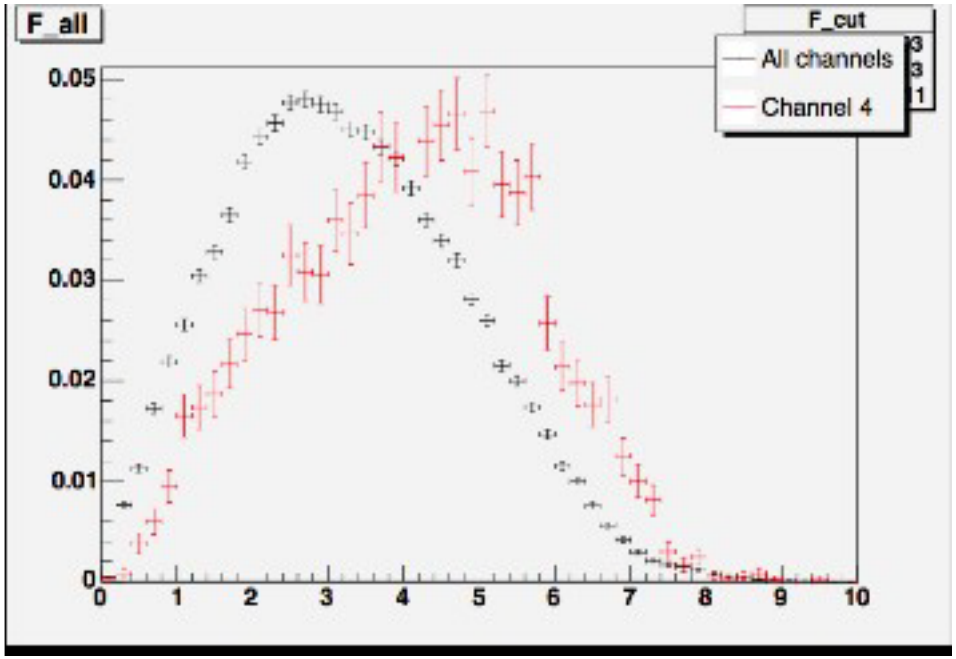
Effective



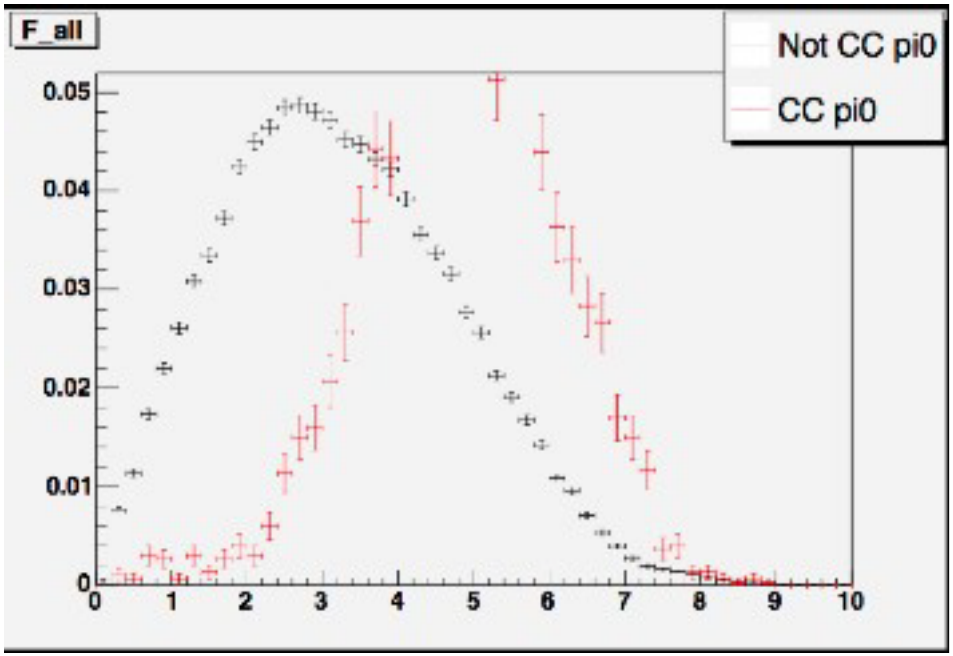
$$m\pi^0 = \sqrt{(2E_1E_2(1-\cos\theta_{12}))}$$

May06 MC: Maximum -log(likelihood) value OneTrackChunk_F[0]

NUANCE



Effective



muon ⟷ electron

muon ⟷ electron

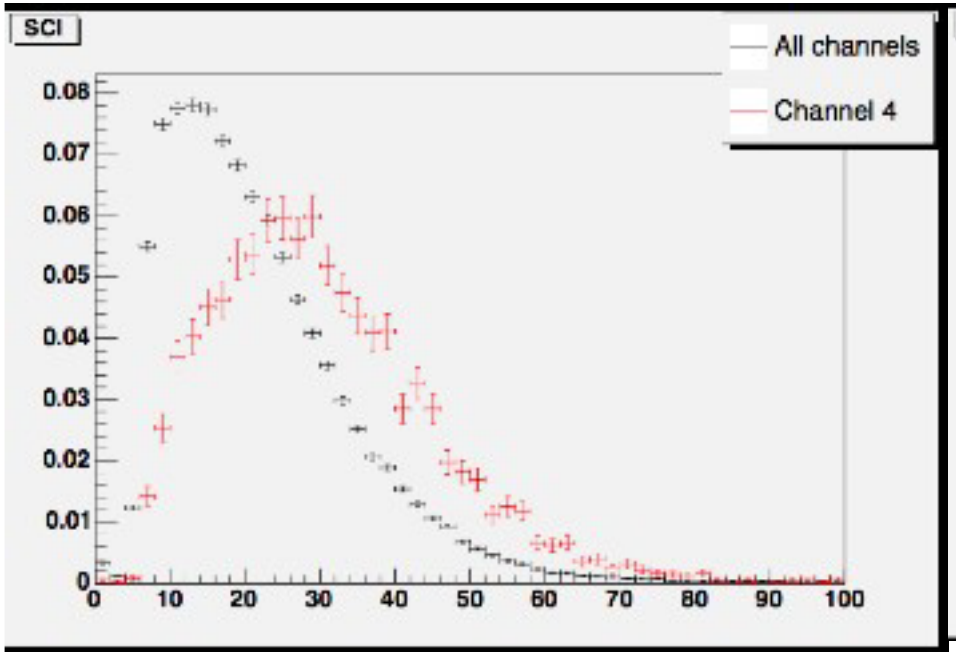
CC π^0 events are more “electron-like”

Scintillation flux
TStancuFlux_SCI[0]

Scintillation flux vs. Cerenkov flux

SCI[0] (y-axis)
vs. CER[0] (x-axis

NUANCE



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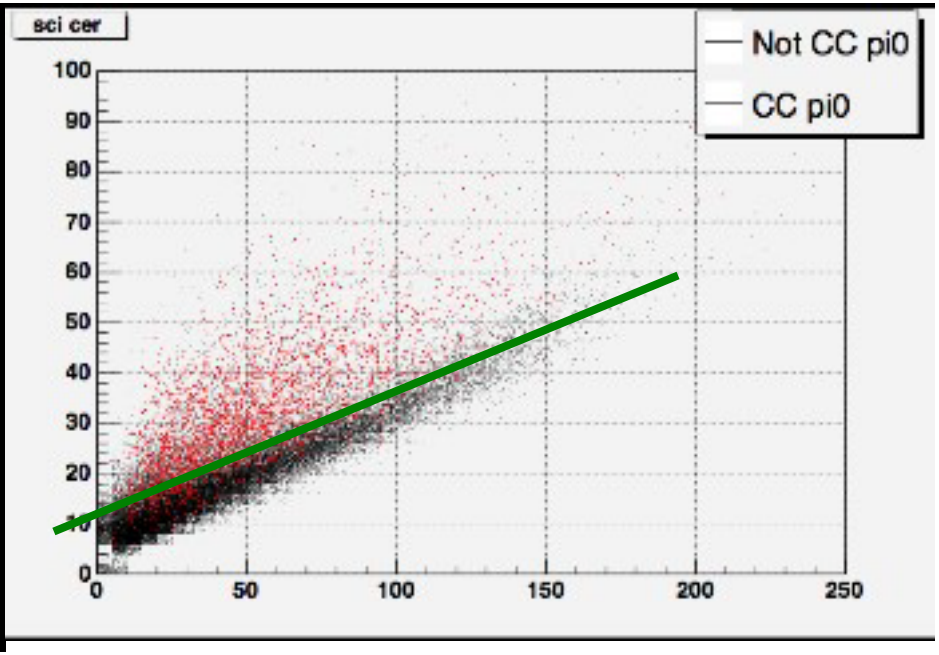
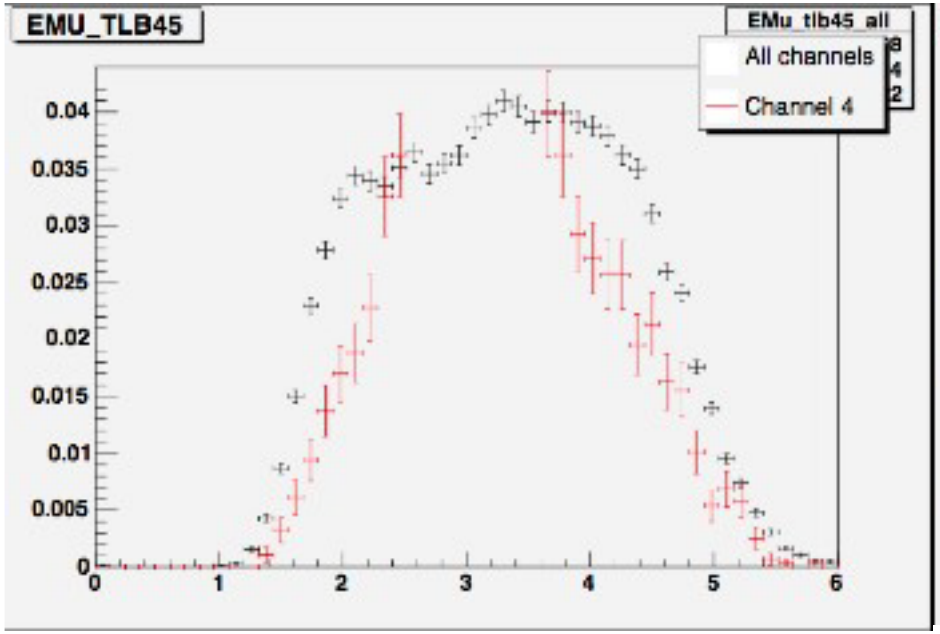


In CC π^0 events, both muon and π^0 lead to more sci flux

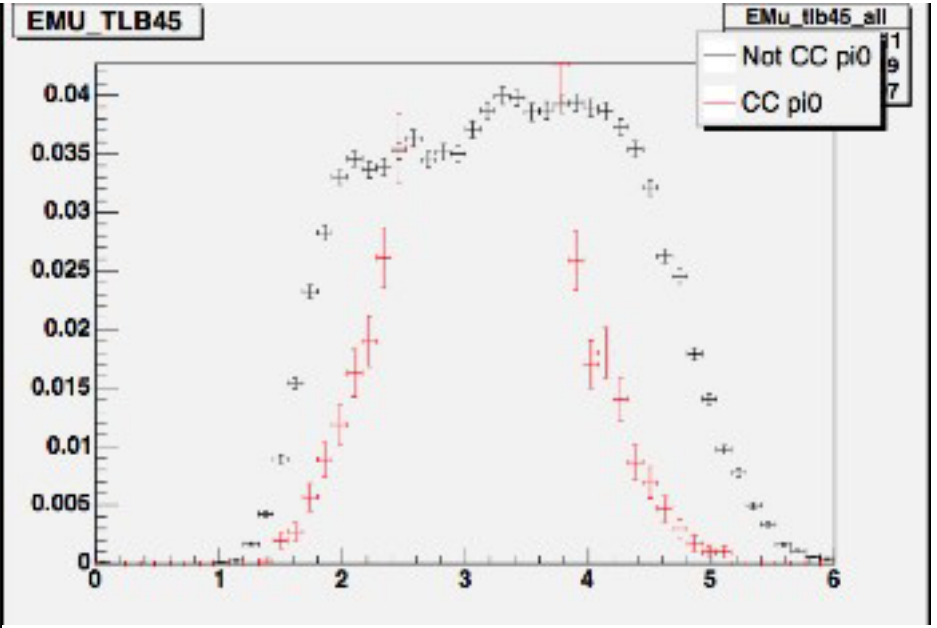
Lends itself to "slanted" cut

T-likelihood ($0.4<\cos\theta<0.5$) StancuVars_Emu_tlb45[0]

NUANCE



Effective



Red peaks extend above the graphs

Other characterizations that separate CC π^0 from background

- Fraction of Cerenkov light in least energetic ring is larger on average (StancuPi0_fcer)
- Reconstructed muon track length is shorter relative to total event energy
- CC π^0s are more energetic and deposit more Cerenkov light

Visible hadronic energy

- It is calculated by subtracting the energy of the muon in CC events from the total visible energy in the first subevent.
- This value will hereafter be referred to as Δ_E.
  - Should be close to 0 for QE events
  - Should be small for π^+ events
  - Should be higher for π^0 events
- Richard Imlay proposed cutting on this value

Calculating Δ_E

- Record visible energy of first subevent: StancuFull_E[0]
- Muon energy calculated from range
  - Calculate track length
  - Divide by oil density to get range
  - Use Morgan's lookup table (in ccpipRecon) to convert range to energy